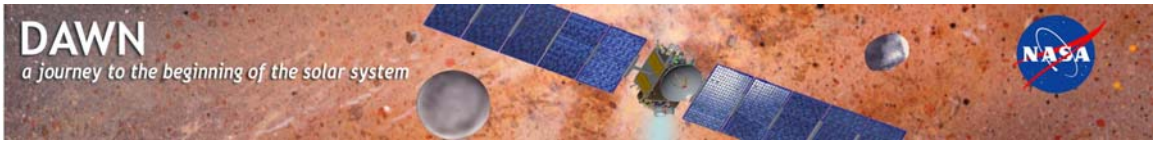

Find A Meteorite

Meteorite Identification

TEACHER GUIDE

BACKGROUND


Meteorite from Vesta

The Find a Meteorite activity introduces the importance of meteorites to the understanding of the origin of the solar system. "Finding meteorites is quite difficult because most meteorites look like Earth rocks to the casual or untrained eye. Even to the trained eye, recognizing meteorites can be difficult" (NASA, 1997). Since scientists believe that some meteorites are pieces of the asteroid Vesta, they may be very old remnants of the solar system in its earliest stages. The activity provides information and insight that allows participants to share scientists' expectations, based on meteoritic samples, of what we will find when the NASA's Dawn Mission visits Vesta and Ceres. Comparisons between actual data and the meteorites here on earth may confirm that we are in possession of very valuable material indeed.

The hands-on activity is an introduction to meteorite identification that aims to help learners differentiate between meteorites, and terrestrial rocks. Students as young as 10 will find the exercise interesting. This activity has been presented with great success at the University of New Mexico Institute of Meteoritics, and a simplified version has been used many times with the general public during Astronomy Day in Albuquerque. This exercise is recommended for presenting individuals and teachers with some background in mineralogy or geology. The Web-based activity http://dawn.jpl.nasa.gov/Meteorite/index.asp is a simplified version of the hands-on activity, and can be used to augment the hands-on activity.

The following are definitions that learners should be familiar with prior to the activity.


Meteorite found in Antarctica
Photo by John Annexstad, NASA JSC

- **Meteoroid** - A piece of rock floating in space. The rock probably came from the asteroid belt between Mars and Jupiter, but some can come from Mars or the moon.
- **Meteor** - "shooting star." This is what the meteoroid becomes when it starts burning up in our atmosphere. Dust from the tails of comets are also seen as meteors. We also see regular meteor showers like the Leonids and Perseids when the Earth travels through dust particles left over from a comet's passage long ago.
- **Meteorite** – Sometimes a meteor makes it to the Earth's surface. The piece of space rock that lands on the earth is called a meteorite. Meteorites are found all over the world.

In this activity learners will get to look at actual samples similar to those that people have sent in to the University as meteorites. Students will decide if these samples are meteorites by using a checklist from the activity, "How Do You Identify a Meteorite." The following is a summary of these characteristics. Most meteorites contain at least some metal and those that have a lot of metal tend to be very dense. If a sample is magnetic, it could be a meteorite, but terrestrial rocks can be magnetic. Some primitive meteorites have little round pieces of stoney material in them called chondrules, but some volcanic rocks may have particles that fit this description. When a meteorite falls through the atmosphere it is heated to the point where the outer surface begins to melt. The result is a rock that contains a thin black or brown coating called a fusion crust. However fusion crusts can weather away and therefore may not be present. The surface of most meteorite samples have features that look like thumbprints called "regmaglypts", which can vary in size from less than a centimeter up to as much as 10 centimeters. Finally, most meteorites will not leave a mark on a "streak plate."

NATIONAL SCIENCE EDUCATION STANDARDS ADDRESSED

Grades 5-8

Science as Inquiry

Abilities Necessary to do Scientific Inquiry

Physical Science

Properties and Changes of Properties in Matter

- A substance has characteristic properties, such as density, a boiling point, and solubility, all of which are independent of the amount of the sample

Earth and Space Science

Earth in the Solar System

- Earth in the Solar System: The Earth is the third planet from the sun in a system that includes the moon, the sun, eight other planets and their moons, and smaller objects, such as asteroids and comets

Grades 9-12

Science as Inquiry

Abilities necessary to do Scientific Inquiry

Physical Science

Structure and properties of matter

- The physical properties of compounds reflect the nature of the interactions among its molecules

Earth and Space Science

Origin and evolution of the Earth system

- The Sun, the Earth, and the rest of the solar system formed from a nebular cloud of dust and gas 4.6 billion years ago.

MATERIALS

- One Fe-metal meteorite and one chondritic meteorite
- 5 or 6 meteor-wrongs (volcanic glass bomb, slag, milling ball, magnetite, basalt, weathered sedimentary rock); enough meteor-wrongs to have one per pair
- 5 or 6 magnets (one per pair)
- 5 or 6 magnifying glasses (one per pair)
- 5 or 6 streak plates (one per pair)

- Activity, "How Do You Identify A Meteorite"

Meteorites and some types of meteor-wrongs can be purchased from rock shops and meteorite dealers. Ideally you would want an iron meteorite and an ordinary chondrite, such as Canyon Diablo or Gibeon for iron meteorites, and El Hammami, Gao, and Gold Basin for ordinary Chondrites. An iron meteorite sample should have regmaglypts visible, as well as a cut and polished face, therefore a slice is less desirable. Chondrite meteorites that show chondrules and fusion crusts are desirable, as well as a sample or slice with a cut or polished surface. Most ordinary chondrites do not have visible chondrules. Meteorite dealers advertise in the popular magazine "Meteorite" (http://www.meteor.co.nz/).

Please inform the meteorite dealer that you will be using the meteorites for educational purposes and you do not want a sample that will crumble when used on a streak plate. Also, please ask about an educational discount.

The samples recommended in the guide are good samples that will be appropriate for class work. You should be able to find a nice sample for around fifteen to thirty dollars. Many of them, like Gao, are about $2.00/gram for small stones, but you will want to find a cut piece. Most dealers have pictures of every sample they sell, and most will take extra pictures if requested. One author states, "I can't remember when I've had a more enjoyable shopping experience." If you have any problems with the dealers, please let us know. jristvey@mcrel.org

A collection of meteorite material embedded in a plastic disk is available for loan from the curator at the NASA Johnson Space Center <http://ares.jsc.nasa.gov/>. They also have a lunar sample disk available for loan. This disk is a good supplemental resource for the activity. NASA also publishes an excellent educator guide entitled *Exploring Meteorite Mysteries* that has good background material on meteorites. This guide can be downloaded at the following web site http://www-curator.jsc.nasa.gov/outreach1/expmetmys/ExpmetMys.htm

PROCEDURE

Part I Introduction

1. Begin the session by having learners complete a word association. On a piece of paper, have learners write down the first thing that comes to their mind when they hear the term "meteorite." Don't give the learners much time to think about it, just have them record their first impression.

TIP

Prior to beginning this lesson, use lesson three, "Searching for Meteorites" from *Exploring Meteorite Mysteries* to help students model the distribution of materials after meteorites and their recovery on various terrains using geography skills.

2. Ask volunteers to share their responses. There is no need to comment on these responses, but listen carefully to the types of answers that are given. Use this information to guide your instruction for this lesson.

3. Explain to learners that in this activity they will get to look at actual samples of the type that people have sent in for identification and you get to help decide if these samples are meteorites.

TIP
Using two different color highlighters learners can highlight information that they understand in one color and information they do not understand in another.

Part II Definitions

4. Learners will gain an understanding of the following terms: meteor, meteoroid, and meteorite. It is recommended that direct vocabulary instruction be used to help learners understand these terms. Research suggests that:

- Instruction that uses new words in context enhances learning.
- Learners must encounter words in context more than once.
- One of the best ways to learn a new word is to associate it with an image.
- Direct vocabulary instruction on words that are critical to new content produces the most powerful learning.

5. Present learners with a brief explanation or description of the new term or phrase from the background information above. For example: "Meteorite: This is a meteor that has made it to the Earth's surface. Meteorites are found all over the world."

6. Present learners with a nonlinguistic representation of the new term or phrase. Show the picture associated with the term "meteorite" from the Dawn Web site.

7. Ask learners to generate their own verbal description of "meteorite."

8. Ask learners to create their own nonlinguistic representation of "meteorite."

9. Periodically ask learners to review the accuracy of their explanations and representations. Repeat this instruction for "meteoroid," and "meteor."

Part III Why are we interested in meteorites?

10. Ask learners to think about why astronomers might be interested in meteorites. After learners respond explain that:

- Studying meteorites is an easy way to study rocks from other planets or from the asteroid belt.
- Meteorites are very old (Ask learners to guess how old). A lot of meteorites formed in the beginning of the solar system (4.5 billion years). So meteorites are like having a time machine that can tell us what things used to be like in the beginning of the solar system.
- Meteorites can be worth a lot of money. Meteorites that come from Mars can be worth up to $1,000 per gram.
- Meteorites can cause damage. Some can cause small amounts of damage like holes in roofs, while others can make very large craters. For example, scientists are studying the 65 million year old crater in Chicxulub, which has a diameter of about 160km, and is the remains of an impact that is believed to have caused the extinction of the dinosaurs.

11. Part of the work at the Institute of Meteoritics (IOM) http://epswww.unm.edu/iom/ is to identify possible meteorites. Tell learners that for today's activity, they will be given

a checklist to see if their sample has all of the characteristics of a meteorite. With this checklist, learners will be able to see if they have a meteorite. If they can check off most of the things on the list, there's a good chance that the sample is a meteorite.

12. Distribute the Activity, "How Do You Identify A Meteorite?" Ask students to read over the information. Clarify any information that the students do not understand.

13. Bring up the Find a Meteorite Web Activity http://dawn.jpl.nasa.gov/Meteorite/index.asp on class computers, and have students experiment with it.

14. Use the activity sheet to complete two quick examples with your learners using the checklist.

Example 1:
Show the students an iron meteorite (but don't tell them what it is). It will not have a fusion crust (A fusion crust is dark colored), it may have thumbprint indentations, called regmaglypts, on the surface, it will be more dense than ordinary Earth rocks, and it will have a lot of iron metal in it, which means that it will be magnetic. An iron meteorite that has been cut and etched with acid will show a Widmanstätten texture, which looks like criss-cross lines on in the meteorite.

Example 2:
Show the students a stony meteorite (but don't tell them what it is). It may have a fusion crust, it may have regmaglypts, it won't be as dense as an iron meteorite, but will be more dense than an ordinary Earth rock, it will have little flecks of metal in it so it will be weakly magnetic, and it may have millimeter-sized round inclusions called chondrules in it.

Part IV Meteorites-*vs*-"Meteor-wrongs."

15. Put learners into groups of 4-5 (if possible) and give each group a mystery sample, which may be one of the following possibilities:
    - Real meteorite
    - Volcanic glass bomb
    - Slag
    - Milling ball or steal
    - Magnetite
    - Basalt
    - Hematite
    - Obsidian
    - Weathered sedimentary rock

16. Have learners look for the characteristics discussed in step 14. Hand out streak plates, magnets, and magnifying glasses. NOTE: Not all meteorites will have all of the identifying characteristics.

17. Have each group present their case for whether or not they have a meteorite. Have the class vote on which sample they think is the real meteorite. Ask learners how they would be able to know for sure if they have a meteorite.

    Still not sure? Look inside and use a powerful microscope to find one of the following characteristics:
    a. Widmanstätten texture (Iron meteorites). Mention the cooling rate of 1

degree per million years.
b. Chondrules (describe).
c. Unique chemical characteristics (e.g. Fe-Ni alloy).

Extension for Facilities with a Scanning Electron Microscope

Use the Scanning Electron Microscope (SEM) to find out if it really is a meteorite.

Introduction to the SEM

1. How does it work?
   - Compare to an optical microscope (50,000 magnification versus 300,000 magnification).
   - Electron Gun? (Compare with a TV). Show that you can use a magnet to move an electron beam (e.g. use the altered TV).
   - Filament similar to a light bulb.
   - Electron beam slams into the sample, producing other electrons and x-rays.
2. What can you look at?
   - Rocks
   - Bugs
   - Microchips
   - Hair
   - Atoms (on TEM)
   - Razors
3. How small is that?
   - Discuss what a micron is.
   - Compare to the width of a human hair.
4. Look at a piece of the meteorite with the SEM and try to determine if it has the Widemenstatten texture (for iron meteorites that have been polished and etched), chondrules, and/or a unique chemical signature(Fe-Ni metal).

Acknowledgements: This activity has been prepared by Dr. Horton Newsom, Dr. Rhian Jones, Dr. Jim Karner, Justin Hagerty, Sherie Pennebaker at the University of New Mexico Institute of Meteoritics, and education consultants from McREL.